



Integrity ★ Service ★ Excellence

AFRL Digital Thread Update

**ERS Annual Technology Meeting
2014**

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Aerospace Systems Directorate**



Why Digital Thread?

Global Horizons

Global Horizons

Final Report

United States Air Force
Global Science and Technology Vision



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9. Manufacturing and Materials

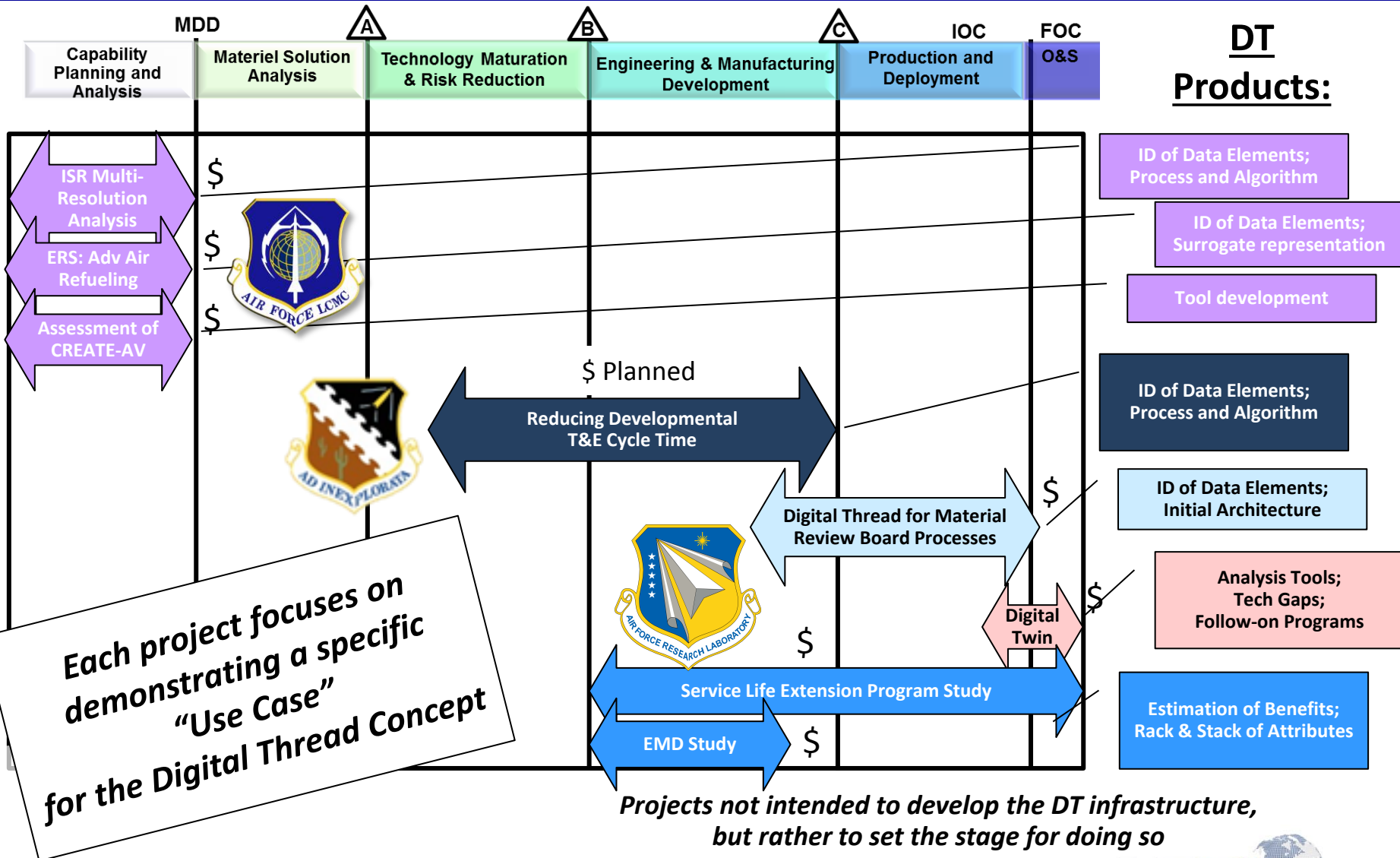
9.3 Game Changers

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Exploiting the three game-changing opportunities below will help the AF meet the need for more rapid development and deployment. The recommendations represent the first steps on the path to future game-changers.

Digital Thread and Digital Twin

Digital Thread and Digital Twin. The concept of a digital thread/digital twin comprised of advanced modeling and simulation tools that link materials-design-processing-manufacturing (Digital Thread) will be the game-changer that provides the agility and tailorability needed for rapid development and deployment, while also reducing risk. State Awareness and System Prognosis advantages will be achieved through the Digital Twin, a virtual representation of the system as an integrated system of data, models, and analysis tools applied over the entire life cycle on a tail-number unique and operator-by-name basis. M&S tools will optimize manufacturability, inspectability, and sustainability from the outset. Data captured from legacy and future systems will provide the basis for refined models that enable component and system-level prognostics. Archived digital descriptions of new systems would greatly facilitate any subsequent re-engineering required in the future. Human performance monitoring will enable adaptation of systems to the “mission capable” state of the operator.



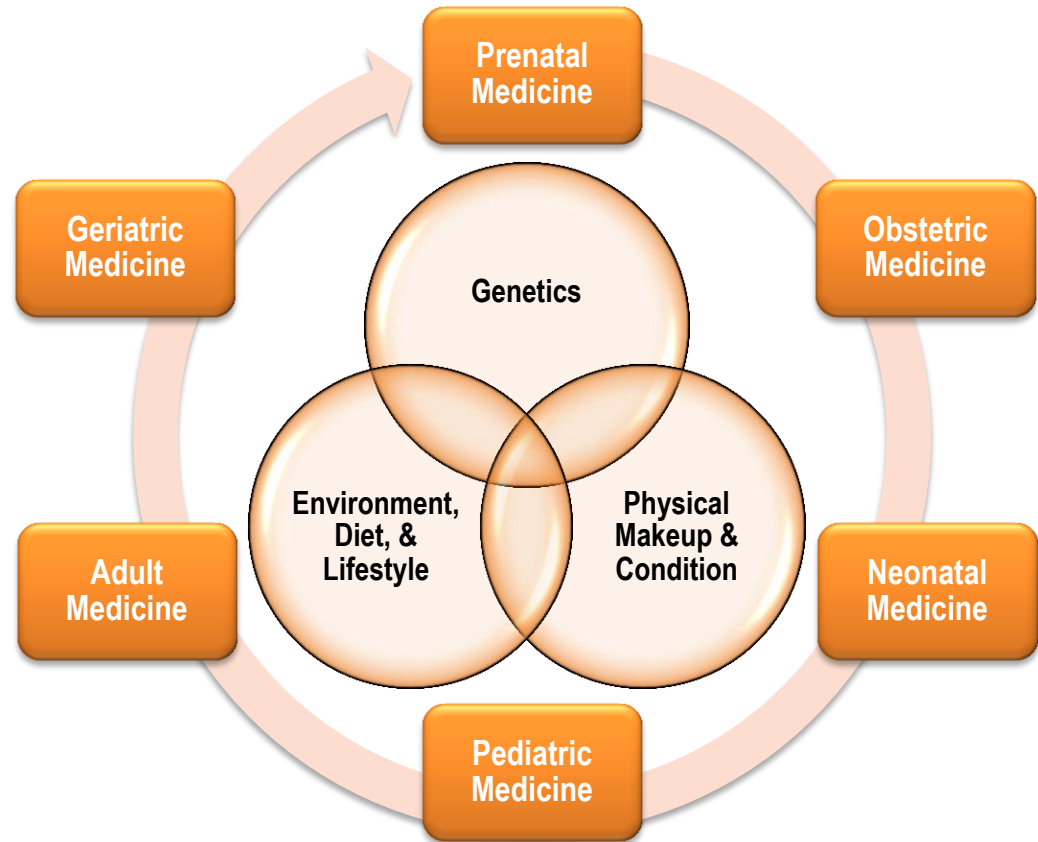


An Analogy: The Future of Healthcare



“TO BE” State:

- Treatments are based on early identification of disease & disease precursors
- Electronic Medical Records & Personal Health Records available to patients & providers
- Preventative medicine & disease treatments are personalized to each patient
- Majority of effort is in predicting, preventing, & managing disease throughout life



Future Healthcare will be
Predictive, Integrated,
Personalized, and Preventative

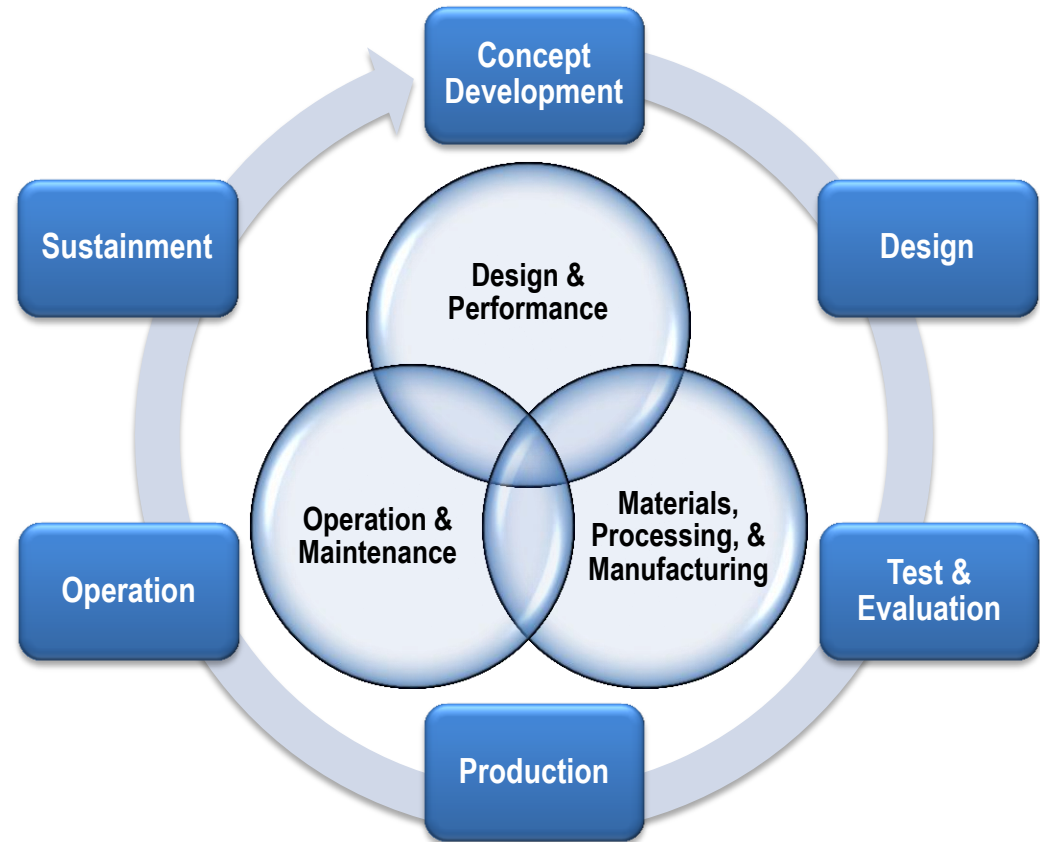


The Future of Aircraft Lifecycle Management



“TO BE” State:

- Maintenance based on early identification of damage & damage precursors
- Individual aircraft history available to operators, maintainers, & engineers
- Preventative maintenance & repairs / retrofits are personalized to each aircraft
- Majority of effort is in predicting, preventing, & managing damage state throughout life



Future Lifecycle Management will be
Predictive, Integrated,
Individualized, and Preventative



The Future of Aircraft Lifecycle Management



“TO BE” State:

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MAIN TECHNICAL GOALS:

- Use **ALL AVAILABLE INFORMATION** in analyses
- Use **PHYSICS** to inform analyses
- Use **PROBABILISTIC METHODS** to quantify program risks
- **CLOSE THE LOOP** from the beginning to the end and back to the beginning of the acquisition lifecycle

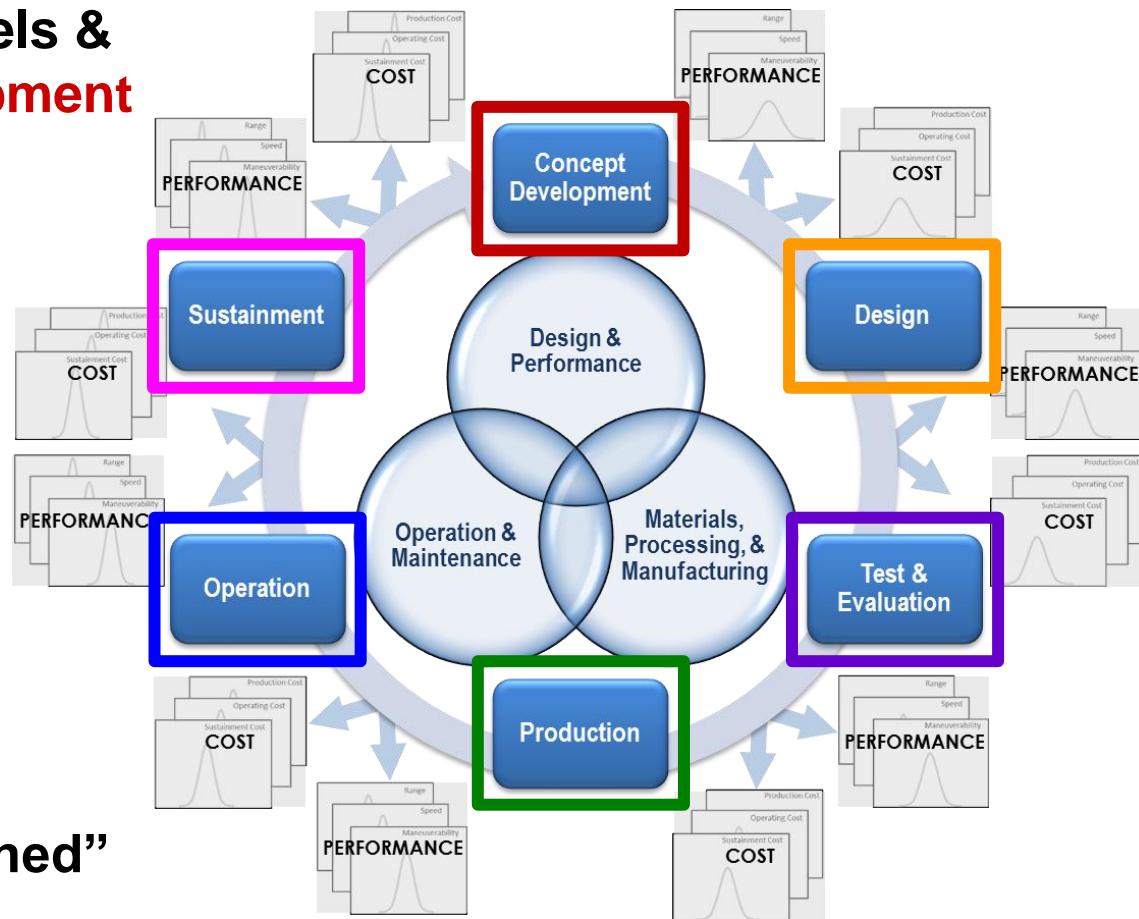
Future Lifecycle Management will be Predictive, Integrated, Individualized, and Preventative



Digital Thread Analysis Progression



- Develop preliminary models & req'ts in **Concept Development**
- Develop detailed “as designed” models & req'ts in **Design**
- Validate/calibrate in **Test & Evaluation**
- Update using “as built” data from **Production**
- Update using “as flown” data from **Operation**
- Update using “as maintained” data from **Sustainment**



Requires formalized framework(s) for linking & updating across both acquisition phases *and* technical domains.



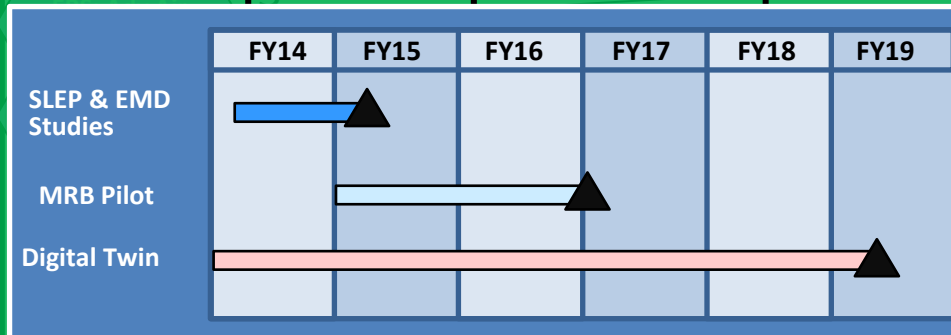
USAF DT Projects:

“Testing the Digital Thread Concept”



DT Products:

AFRL Digital Thread Projects



Each project focuses on demonstrating a specific “Use Case” for the Digital Thread Concept



Digital Thread for Material Review Board Processes

ID of Data Elements;
Initial Architecture

Analysis Tools;
Tech Gaps;
Follow-on Programs

Digital Twin

Service Life Extension Program Study

EMD Study

Estimation of Benefits;
Rack & Stack of Attributes

*Projects not intended to develop the DT infrastructure,
but rather to set the stage for doing so*

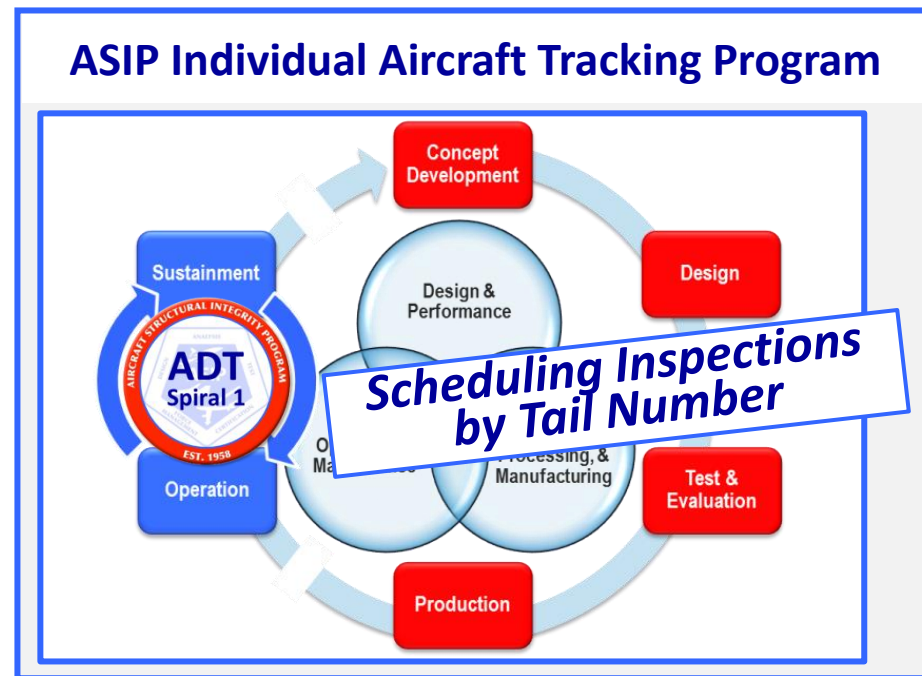


The “Airframe Digital Twin for Individual Aircraft Tracking” Use Case



Individual Aircraft Tracking Program (IATP)

- Required by MIL-STD-1530C
- Used to adjust structural inspection, modification, overhaul, and replacement times based on the actual, measured usage of the individual aircraft
- Used to forecast when aircraft structural component life limits will be reached
- Requires development of analysis methods and collection of actual usage data



Scope of the “ADT IATP” Use Case:

- Acquisition Activity: Operation & Sustainment
- “Performance” Parameters: Structural Life Predictions
- Applicability: Airframe Structures



Two “Probabilistic & Prognostic IAT” ADT Spiral 1 6.2 Contracts Underway



USE ALL INFO

FDR Data
NDE Data

USE PHYSICS

Fluid Dynamics
Structural Mechanics
Materials Sci & Eng'g

USE
PROBABILISTIC
ANALYSIS

CLOSE LOOP

Automated
Probabilistic Updating



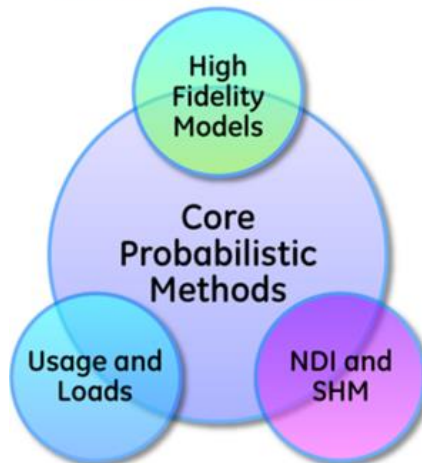
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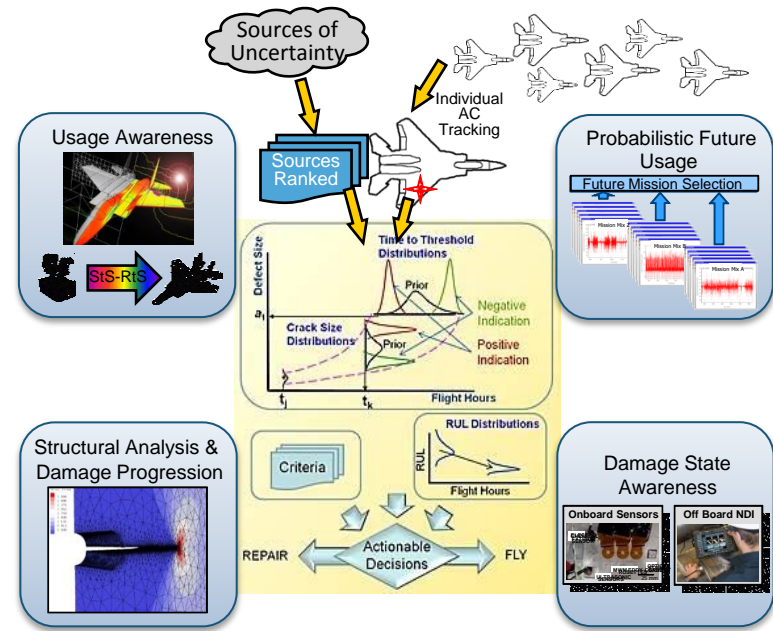
Scalable
Accurate
Flexible
Efficient
Robust



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Open
Flexible
Extensible
Maintainable



https://www.fbo.gov/index?s=opportunity&mode=form&id=0b10f8d15837d4ad47ca81da9e97cfcd&tab=core&_cvview=1



“The Digital Thread for Material Review Board Processes” Use Case



The Material Review Board

- Decision-making Authority for Engineering Disposition of Non-conforming Articles during Production
- Convened when material non-conformances are discovered after significant value has been added to the manufactured article
- Dispositions require an assessment of the impact of the nonconformance and potential rework/repair actions on the performance of the article
 - Information gathering, engineering analysis, repair development
 - Impact to production schedule and cost

Scope of the “The Digital Thread for MRB” Use Case:

- Acquisition Activity: Manufacturing/Production
- “Performance” Parameters: Key Characteristics
- Applicability: Nonconforming Articles



Two “DT for MRB Processes”

6.3 Contracts Awarded



DT for MRB
Infrastructure

DT for MRB
Tech Data
Package
Standards

DT for
Enhanced MRB
Efficiency

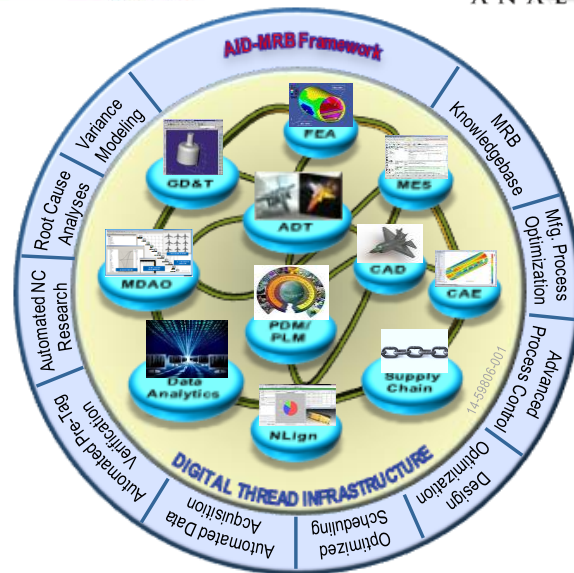
DT for
Reduced MRB
Occurrences

DT for MRB
Metrics &
Business Cases

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Etegent
TECHNOLOGIES INC

NLIGN
ANALYTICS



RJ LEE GROUP



Pratt & Whitney
A United Technologies Company



<https://www.fbo.gov/index?s=opportunity&mode=form&id=31b783542ca9a65f06fc8ee98f5a379d&tab=core&tabmode=list&=>



AFRL Digital Thread Studies



Service Life Extension Program

*Acquisition Activity to Extend
the Life of a Fleet of Aircraft*

Engineering and Manufacturing Development

*Third Phase of the System
Acquisition Life Cycle as defined
and established by DoDI 5000.02*

- 6-mo. Studies w/ Industry
- Focus on Airframe Structures
- Use Case Brainstorming
- Use Case Definition
- Estimation of Benefits



LOCKHEED MARTIN



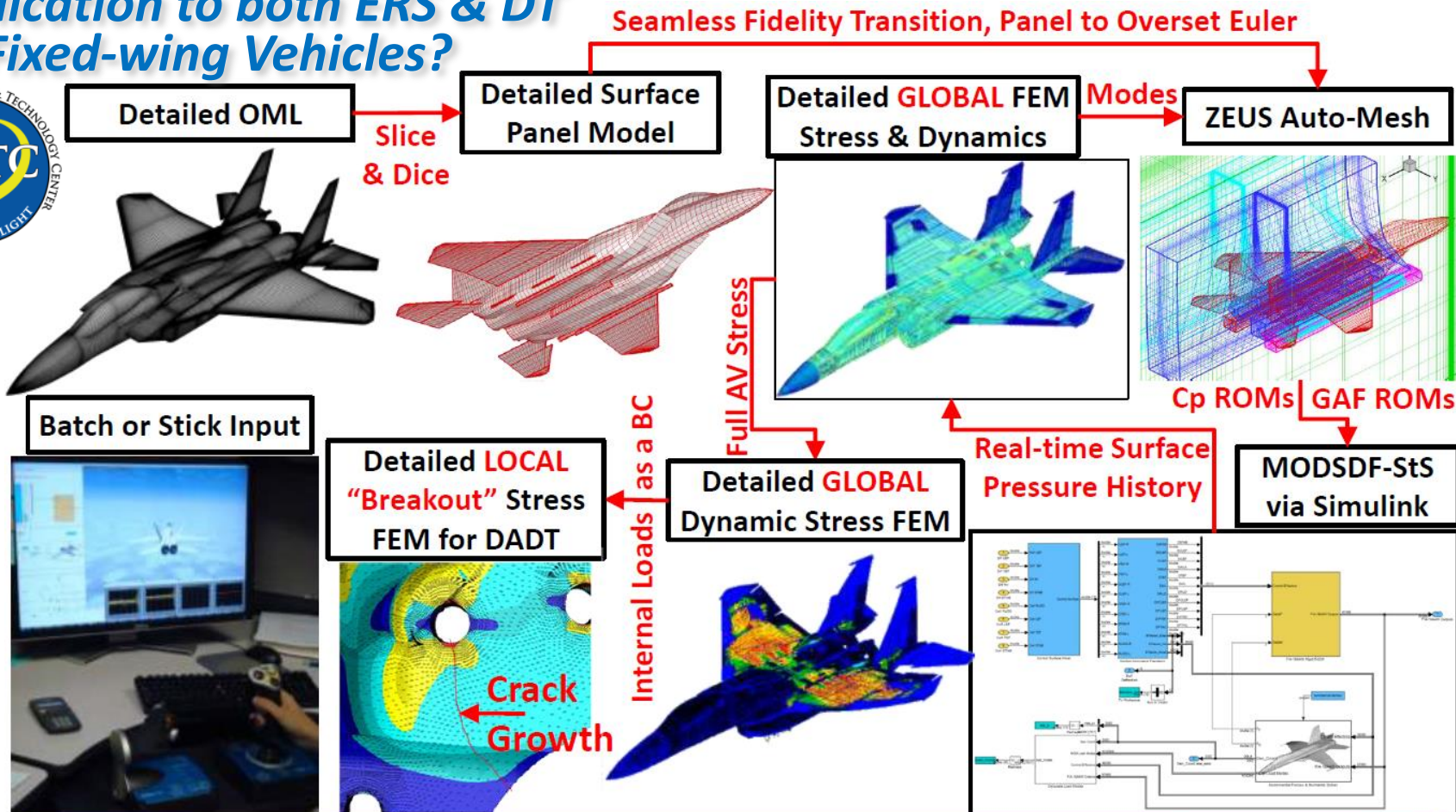
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Stick-to-stress Dynamic Flight Simulation Technology



Application to both ERS & DT for Fixed-wing Vehicles?



Detailed Mission-Vehicle-Pilot-Specific Dynamic Stress Histories for Fatigue, DADT & Fleet Management Purposes, all via Real-time Euler-based Simulation

<http://www.meetingdata.utcd Dayton.com/agenda/asip/2013/proceedings/presentations/P7299.pdf>